

about a 10 per cent change in the intensity of solar radiation.

c. Since the changes in solar radiation are aperiodic and occur more or less spontaneously, the effect on the earth's magnetism is generally of a threefold character: (1) An alteration in the diurnal range, (2) perturbations both of the world-wide and the local kinds, (3) an outstanding residual effect such as to alter the daily mean values of the magnetic elements by an amount 10 to 100 times that caused by the regularly-progressing secular variation. The magnitude of the effects may at times exceed the average ones described in (a) and (b), dependent upon peculiar local conditions (ionizations) of the upper atmospheric layers. Changes in solar radiation may thus furnish sufficient cause for the ever-present minor perturbations and elementary waves or pulsations of the earth's magnetism.

d. The daily noncyclic changes in the earth's magnetism, as found on magnetically quiet days by previous investigators, furnish an additional check on the foregoing results, their quantities harmonizing completely both as regards sign and magnitude with those given here. It is found that on consecutive quiet days the magnetic constant is, on the average, larger on the second day than on the first, the increase being equal to that which would be caused by an average daily change in the solar constant. Moreover, the reason why the magnetic constant, or the horizontal intensity, is larger, on the average, on the second quiet day is because, on the average, the solar constant is slightly smaller on the second day than on the first. The relation between solar change and magnetic change during consecutive quiet days is precisely of the same sign and amount as given in (b).

e. If the quiet-day magnetic effect were to persist throughout the year, it would cause a secular variation fully ten times that generally observed. However, the quiet days are in the minority, being exceeded three times and more by unquiet days on which the magnetic effect is of an opposite or compensating kind to that of the quiet day. Since these acyclic effects appear to be associated with solar changes, and since the latter are not periodic, but more or less sporadic, there is an outstanding effect at the end of the year which causes an irregularity in the regularly-progressing secular change. Accordingly, there should be found some correspondence between annual changes of the solar constant and annual magnetic changes. This is found to be the case. Since the solar-constant changes occur only approximately in accordance with sun-spot activity and since the magnetic changes are found to conform so closely to those in the solar constant, an explanation is obtained as to why the irregularities in the magnetic secular change do not always synchronize with changes in solar activity as measured by the sun-spot numbers nor correspond in magnitude to them.

THE RADIOACTIVE DEPOSIT FROM THE ATMOSPHERE ON AN UNCHARGED WIRE.

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In the Physical Review for 1908 appeared an article by the author on the "Radioactivity of the Atmosphere," which stated that a considerable amount of active deposit could be obtained from a smoky atmosphere on an uncharged wire. This deposit was the same in nature

as that obtained when the wire was charged to a high negative potential, having decay curves varying between the same wide limits.

Mr. Wilson, at Manchester, England, published a paper¹ in which he stated that he could get no appreciable deposit on an uncharged wire, though he got an effect when the wire was negatively charged. This seemed strange, as one would expect a considerable effect at Manchester, which by report is as smoky as Cincinnati. Granting that the conditions are favorable at Manchester for obtaining the active deposit, Mr. Wilson's negative result may be explained in several ways. With a wire of only 50 feet he could not expect to obtain enough deposit to measure unless he used a very sensitive apparatus. The active deposit on an uncharged wire is in general small compared with that on a charged wire. Careful correction or elimination of the "natural leak" of the apparatus would be necessary. The author used 360 feet of wire and a very sensitive balance method in which the natural leak was eliminated.

Mr. Harvey, at Denver, Colo., states² that he could obtain a very small effect on an uncharged wire in an atmosphere which was very clear as far as smoke was concerned but contained a considerable amount of dust.

There does not seem to be much doubt that in an atmosphere containing small nuclei, such as dust, smoke, rain, and snow, one can collect a radioactive deposit without the aid of a strong electrical field. These nuclei act only as carriers and are drawn to the wire by diffusion, or wind. It is probably true that in case of smoke and dust particles the nuclei are sometimes charged. Negative nuclei would therefore be the most efficient as collectors of the radioactive matter, which is positively charged. Any wire insulated in the air would be subject to the effect of the natural potential gradient of the atmosphere which is normally negative with respect to earth. Except in rare cases this potential gradient would not be comparable with the high ones usually used by experimenters in different parts of the world.

The author could get an active deposit whether the wire was insulated from, or connected to, the earth, and even a small trace when it was positively charged.

The present paper gives an account of further observations made during the last 14 months under different atmospheric conditions. They are of considerable local interest, since for several years the Smoke Abatement League has labored to decrease the amount of smoke, and in the last year or two has been quite successful; so much so that to-day the average clearness of the atmosphere at Cincinnati is greatly improved over what it was a few years ago. It was therefore of interest to see if this was having any effect on the active deposit.

The experiments were carried out in exactly the same place and with the same apparatus as those in 1908. The wire was 360 feet long, running as an endless belt over pulleys. The active deposit was rubbed off onto a piece of cotton, or linen, and tested in the null reading "balanced" electrometer devised by the author. The electrometer was made very sensitive, and an uranium oxide standard used. Before each reading the "natural leak" was exactly balanced in the testing chamber and the standard, so that the only ionization measured was that of the active deposit.

By several preliminary experiments the conclusion was reached that nearly all the active deposit was removed from the wire by rubbing. At any rate only the outer layers of the deposit would be very active, since in a

¹ Wilson, Phil. Mag., 1909.

² Harvey, Phys. Rev., 1909.

24-hour exposure the first active layers would have decayed away by the time of removal.

Observations were made on most days that the weather would permit. Those during the summer months are rather incomplete, as the author was absent from the university during that time. Exposures varied from about 15 hours to several days. An exposure longer than one day did not seem to make much difference in the active deposit obtainable. On many days decay curves were taken over as long a range as possible.

The results obtained for the last 14 months are shown in Tables 1 and 2. Table 1 [omitted] gives the complete observations for the highest and lowest months; Table 2 the summary for each month. The activity is given in terms of uranium oxide. A reading of 100 is equal to that of 1 square centimeter of uranium oxide of about nine-tenths the thickness of the McCoy standard ($100 = 5.2 \times 10^{-13}$ amperes). A characteristic set of decay curves are also shown.

TABLE 2.—Summary of measurements of radioactivity of deposits on a 150-foot wire at University of Cincinnati.
[In terms of uranium oxide: $100 = 5.2 \times 10^{-13}$ amp.]

Month.	Activity.			Number of obser- vations.	Periods of rain.
	Maximum.	Minimum.	Average.		
1914.					
March.....	375	47	149	9	3
April.....	300	48	163	20	4
May.....	520	50	183	23	4
June.....	391	120	232	9	2
July.....	308	86	132	5	1
September.....	268	125	191	5	1
October.....	500	68	196	23	10
November.....	580	48	316	19	3
December.....	414	50	193	13	9
1915.					
January.....	443	54	223	18	8
February.....	410	28	181	13	5
March.....	268	0	170	18	5
April.....	207	68	125	14	4
May.....	396	100	242	18	10
Mean.....			193		

The following summary will serve as a discussion of the results obtained:

1. It has been clearly shown that an active deposit can be obtained on an uncharged wire in a smoky atmosphere, such as exists at Cincinnati.

2. From the decay curves [figure omitted] it can be readily seen by careful examination that the active deposit consists of a mixture of the various disintegration products of radium. All the curves can be divided into three classes: Those which are at first convex upward followed by concave upward; those which are concave upward, then convex upward, and finally concave; and those which are very approximately exponential over their complete range. The periods (half decay values) vary from 8 to 50 minutes. A common exponential has a period of about 28 minutes (Radium C). Of course the deposit is a chance mixture, which accounts for the great variation in the decay curves. Deposits have been taken which differed by only a few hours, and which showed entirely different decay curves.

3. On no occasion could a decay curve be obtained which showed a period long enough to be taken for the thorium products. If it was present at any time it was never greater than the experimental error, certainly not greater than 10 per cent. This is in sharp contrast with the results shown in 1908 for a charged wire, when the thorium products were sometimes present in proportions as great as 30 to 40 per cent. It must therefore be that

the thorium products are present in the air in small quantity compared with the radium products, or that they do not collect readily on smoke particles.

4. The amount of soot deposited varied through wide limits, the maximum amount collected in 24 hours being about 0.12 gram. It was found that in general a large amount of soot indicated a large amount of activity, although there were several cases where a large activity was obtained from a small deposit of soot. I think it can be safely said as a rough approximation that, if the radioactive matter in the atmosphere remains the same, the amount of activity on the wire is proportional to the amount of soot deposited. This, of course, would be only true for a steady state up to equilibrium. An interesting case was observed once. One day the activity was 90 with clear weather. During the night there occurred one of the heavy smoke fogs which used to be common to Cincinnati, but now more rare. In the morning the activity was 448. The next day was clear again and the activity dropped to 100. The normal activity was thus low, but the heavy precipitation of smoke deposited a large activity momentarily on the wire.

5. The activity does not seem to vary greatly in summer and winter, but the results so far obtained would seem to indicate maxima and minima periods. A maximum occurs around November and December and a minimum around April. A possible reason for this would be the following: At the approach of winter the production of smoke particles in the air is greatly increased, due to inefficient stoking and to the bad condition of the furnaces lying idle all summer. By late winter more efficient operation has been obtained, with the result of much less smoke. It is a fact that the amount of soot in the air here in early winter is much greater than in late winter. In November the deposit was very thick and black, while in April it was light and gray and mixed with dust. Both months were very fine. In May, though the weather was very wet, the activity was very much greater than in April. Whether actual maxima and minima occur in the amount of active matter in the air is not yet certain. Future observations over a long time may give results of interest.

6. Winds from northwest to southwest in general give the largest activity, while those from the east give the smallest. Winds from the former quarter in Cincinnati blow over the smoky part of the city and also bring fine weather. East winds come from over the residential parts.

7. The effect of rain is very certain. A heavy continued rain always clears the air of the activity. If the weather clears up with strong west winds, the activity rises rapidly to its normal value. Before a rain the activity decreases gradually. Even during a rainstorm one can often obtain a small amount of activity by rubbing the sooty water from the wire and then drying the cloth. On one or two occasions, even in fine weather, not enough active deposit to be measured could be obtained.

In conclusion, one can say that the results enumerated and discussed in this paper fall into line with the general results on the radioactivity of the atmosphere observed by different experimenters in many parts of the world, the deposit on an uncharged wire being due to the smoke nuclei in air acting as carriers. The actual deposit at any time is a chance diffusion mixture in all proportions and states of decay of the radium products present in the atmosphere.